

Cairo Air Improvement Project Compressed Natural Gas Component

Sustainability Plan for CNG Bus Pilot Fleet

Chemonics International, Inc.
USAID/Egypt, Office of Environment
USAID Contract No. 263-C-00-97-00090-00

March 2004

INTRODUCTION

The purpose of this document is to assist the Cairo, Egypt Public Transit Sector in addressing sustainability issues regarding their current and future CNG bus fleets.

The report is divided into 3 parts:

- > The first part is a practical guide for the Operations Managers at the garages.
- ➤ The second part is intended for Executive Managers and captures broader policy and management issues.
- ➤ The third part is several appendices which include:
- CAIP fleet chronology, a brief history of the CNG Bus Pilot fleet
- Vendor contact information
- A Training summary
- Reference documents

The Cairo Air Improvement Project (CAIP) as funded by the United States Agency for International Development (USAID) and implemented in partnership with the Egyptian Environmental Affairs Agency (EEAA) and the Ministry of Petroleum (MOP) produced this report based on lessons learned during the development and implementation of the CNG Bus Pilot Fleet. The CNG Sustainability report submitted herein offers observations, recommendations and information critical to the successful operation and future expansion of the CNG Bus Fleet.

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Practical guide for Operations Managers and key recommendations



Fuel Quality

- ♣ CNG fueling quality was identified as a critical requirement in the early stages of the CAIP project. The fuel companies provided chromatograph readings proving the prerequisite fuel quality to the satisfaction of all parties. When a new high-flow, fast- fill fueling facility was constructed at the first CNG bus maintenance garage, fuel quality was never questioned. It was later discovered that the fuel company did not investigate the quality of gas being provided by a pipeline that was not previously on the CNG vehicle distribution network. Lesson learned? Assume nothing, question everything and verify, verify, verify reported results.
- Compressor oil carryover from CNG fueling stations remains a significant but manageable problem throughout the natural gas vehicle industry. Oil carryover has been so excessive from local suppliers that some high-pressure valves on the CNG buses have failed, and significant amounts of oil were found in the on-board storage tanks.
- ♣ Fuel quality must be controlled- it is imperative that the relationship between the gas companies and the bus companies be well defined contractually and that both parties work to keep the relationship productive. Agreements must provide assurances regarding fuel quality, compressor oil carry-over and fuel facility maintenance.

- CNG stations should be required to describe in detail the equipment, techniques and technologies they will employ to control oil carryover, and demonstrate their effectiveness.
- ♣ If possible, government resources should be used to help existing and future end users of CNG stations obtain comprehensive maintenance agreements with skilled and reputable companies to maintain CNG stations.
- Drain low pressure fuel filters daily to assist in minimizing the amount of oil being introducing into the bus fueling system
- Inspect fuel fill point daily. If oil residue is present, it is an indication that compressor oil carry over is excessive. Contact fuel supplier immediately, they must then address fueling facility maintenance issues.



Training

Integrating a new technology takes persistence and patience. A comprehensive training program for understanding and maintaining natural gas buses is often cited as one of the most crucial elements for success by CNG bus fleet managers. Maintenance workers need to be familiar with the new technology in order to troubleshoot and repair problems.

The commitment to a proactive training program will guarantee that equipment life will be extended and maintenance costs will be minimized. Knowledgeable technicians take less time to diagnose and repair vehicles, minimizing labor charges and downtime of buses.

Basic language, literacy and computer skills are also necessary prerequisites for the successful maintenance of the CNG fleet. Managers must actively pursue giving their employees the skills necessary to do the job right. Orientation and on-going training programs must continue as the garages experience employee turn over.

Assigning the right person to the right job will go a long way towards increasing vehicle reliability. Staff changes within GCBC and CTA have created serious challenges. Some previously trained staff is no longer assigned to the CNG divisions and critical CNG expertise left with them. If management and the maintenance staff do not clearly understand the CNG technology, safety risks can be high and vehicle reliability will be negatively impacted.

- ♣ The institutionalised training capabilities at the bus companies can be enhanced. CTA has a training department that acts as the central repository of all training materials. Institutionalising and implementing on-going training programs would be of great benefit. The need for on-going training cannot be overstated training is not a one-time effort. It is a cost effective investment in improving fleet reliability and reducing operating costs.
- ♣ Refresher training courses should be given approximately every six months to reinforce previous training and to introduce current methods and concepts. Continuous training would not only maintain the skills and knowledge of the current CNG personnel, but would also provide the bus companies with developed curricula in order to train new candidates. Over the course of time, the CNG teams will change, but an established training regime would allow for and facilitate the inevitable turnover in personnel.
- Establishing accessible maintenance libraries at each maintenance garage, and a comprehensive on-going training and certification program will assist in the sustainability of the CNG fleet.

CNG FUEL CYLINDERS

CNG Fuel cylinders

Lincoln Composite CNG Cylinders must be inspected, repaired and/or replaced only by authorized personnel. Responsibilities and Authority for CNG Fuel System work is defined as follows:

Only authorized CTA/GCBC persons are allowed to:

- Inspect Lincoln composite CNG cylinders
- Change or re-secure a CNG line or CNG Cylinder Mounting Strap
- Vent Fuel

CTA Trained and authorized personnel:

Eng. Sedky Ezzat Mansour	
Eng. Wagdy Mohamed Abdel Wahab	
Mr. Abdel Aziz Sayed	
Mr. Ezzat Saad Salem	

GCBC Trained and authorized personnel:

Eng. El Sayed Ali Ibrahim
Eng. Shahhat Mohamed Ibrahim
Mr. El Sayed Labib Ahmed
Mr. Alaa Khairy Abdel Fattah

Only authorized NGVC and Gas tech persons are allowed to:

- Inspect Lincoln composite CNG cylinders
- Change or re-secure a CNG line or CNG Cylinder Mounting Strap
- Replace a Pressure Relief or Fuel Fill Valve
- Vent Fuel
- Re-Certify Lincoln Composite CNG Cylinders
- Remove Lincoln Composite CNG Cylinders
- Install Lincoln Composite CNG Cylinders
- Repair Lincoln Composite CNG Cylinders

NGVC and Gas Tech Trained and authorized personnel:

NGVC
Eng. Ahmed Mahmoud El Sayed
Eng. Mohamed Bahgat Abdel Hamid
Mr. Hamdt Fayiad
Mr. Mustafa Awad
Gas Tech.
Eng. Taha Ahmed Mahmoud Ahmed
Eng. Khaled Abdel Aziz Hussein
Mr. Sayed Ahmed Sayed
Mr. Mohamed Mohamed Abdel Hady Haridy

Note: All Lincoln Composite CNG Cylinders shall be inspected and re-certified every 36 months by authorized personnel.

- Managers must ensure that only certified, properly trained and staff are allowed to perform maintenance related to the CNG fuel system.
- Managers must ensure that the CNG Cylinders are inspected and re-certified every 36 months by authorized personnel.

OPERATIONS AND MAINTENANCE

Operations and Maintenance

The outcome will be less than satisfactory no matter what type of future CNG bus goes into the public transit bus fleet unless basic maintenance practices are followed. Efforts must continue to ensure maintenance is performed as required.

The quality of vehicle maintenance has a significant impact on sustainability. Knowledgeable technicians take less time to diagnose and repair vehicles, minimizing labor charges and downtime of buses.

A properly performed O&M program not only identifies component problems and failures early, but also allows for advance planning and inventory control for spare parts. An operations and maintenance manual was developed and is now being used as a guideline at both bus companies. The topics covered in the manual include:

- Emergency procedures
- Standard operating procedures
- Preventive maintenance
- Draft policy recommendations
- Record keeping
- Towing
- Employee orientation
- Safety Policies
- Training/certification and re-certification

With the technology transfer now successfully accomplished, the use of new skills must be effectively managed. CTA and GCBC should continue efforts in failure and trend analysis, policy monitoring and enforcement, on-going training and certification programs. These efforts will assist in the sustainability the CNG Fleet.

Availability of spare parts is a serious issue that will continue to require the attention of the bus companies and the local dealers. The dealers are reticent to keep a lot of expensive spares in stock that may or may not be purchased by the bus companies.

- Adhering to scheduled maintenance is critical to the sustainability of the CNG fleet. Continuous emphasis must be placed on monitoring and enforcement of routine maintenance.
- ♣ Improvements in procedures to diagnose problems must be enhanced. Vehicle down time and the costs for repairs are increased by "trial and error" methods of diagnosis.
- ♣ An incentives program to reward the proper operation and maintenance of the buses among the organizations' CNG teams is highly recommended. The establishment of an Employee Recognition and Rewards/Motivation program would likely assist in quality control efforts and would be an important step towards ensuring sustainability of the CNG fleet.
- ♣ The bus companies must plan in advance for spare parts needs; take into account lead-time and order accordingly. Failure to proactively work with the local dealers to procure parts will continue to cause unnecessary vehicle downtime.
- ♣ Both bus companies need to continue their efforts in the monitoring and enforcement of scheduled maintenance by using the Computerized Maintenance Management System (CMMS).

COMPUTERIZED MAINTENCNE MANAGEMENT SYSTEM (CMMS)

Computerized Maintenance Management System (CMMS)

Realizing that Data management is an essential element of running a large fleet, both CTA and GCBC further recognize the importance of utilizing Information technology (IT) and integrating it within its operation.

CAIP has provided a locally developed computerized maintenance management system (CMMS) to enhance the capability of the Garage Managers in identifying costs and in performing failure and trend analysis. (Implementing a CMMS has helped many organizations world wide improve their operational efficiency while decreasing operation and maintenance costs). The focus is to use technology as a tool to manage more effectively.

Reports through CMMS will measure compliance and the impact on equipment downtime as evidence of a successful preventive and predictive maintenance program.

Over time, the benefits that CTA and GCBC will be able to derive from CMMS will be:

- Improved replacement parts inventory
- Increased fleet reliability and efficiency
- Reducing excess and obsolete parts
- Lowering inventory cost
- Increased operational capacity
- Reducing capital expenses
- Extended vehicle life
- Reducing vehicle down time
- Developing internal benchmarks
- Reducing maintenance cost
- Increasing craft-skill effectiveness

Recommendation

The effective utilization of the Computerized Maintenance Management System will greatly enhance the capability of the Garage Managers in identifying costs and in performing failure and trend analysis only if used effectively. Merely gathering the information is not enough, data integrity must be verified and actively using the information will require a commitment from Garage Management.

CUMMINS ENGINE UPGRADE PROGRAM

Cummins Engine Upgrade Program

The CNG bus fleet (using the Cummins 8.3 CNG engine) has accumulated more than 10,000,000 km (an average of 200,000 km/bus). Due to the accumulated mileage, many engines are now due for overhaul.

To enhance the sustainability of the CNG bus fleet, USAID has decided to replace the 50 existing Cummins 8.3 CNG engines in the public transit bus fleet with Cummins latest technology 8.3 C Plus CNG engines.

The new engine upgrade program will include:

- Additional spare parts
- Engine installation
- New wiring harness
- 4 A 2 year, unlimited mileage warranty on parts, labor and workmanship
- All special tools, New diagnostic software and software support
- Driver, engineer and service technician training courses
- ♣ All existing parts stocks owned by CTA and/or GCBC not suited to the C Gas Plus product, will be exchanged for equivalent C Gas Plus parts free of charge

A summary of expected benefits over the existing engine:

- The new engine has the ability to detect knock and reduce or eliminate it to protect the engine against severe damage
- New compression ratio (10:1) to help decrease emissions and increase spark pluglife
- New piston design to help reduce oil consumption and allow for quick engine break- in
- Increased diagnostic capability, this will allow ease of troubleshooting and maintenance practices
- The ability to run on lower quality fuel
- New Sensors for:
 - Knock
 - Fuel inlet pressure
 - Fuel outlet pressure/temperature
 - Exhaust back pressure
 - Engine oil pressure/temperature

- On the job training
 - For 2 years, CTA and GCBC have an opportunity to work side-byside with the local Cummins dealer. The dealer will be working at the bus company garages on warranty issues, diagnosing and making repairs and/or adjustments on the new CNG engines as necessary.
 - CTA and GCBC should take advantage of every opportunity they can to ask questions, observe and learn when the local dealer is working on their buses.
- Closed Crankcase Ventilation filter (CCV)
 - A clogged CCV filter can cause excessive crankcase pressure which will then cause lubricating oil to migrate into the combustion chamber. <u>Excessive oil entering the combustion chamber can result</u> in catastrophic piston failures. CTA and GCBC should ensure that the CCV filters are kept clean and replaced as necessary.
- Supplemental Coolant Additive (SCA)
 - The Fleetguard "water filter" contains a fully formulated SCA which is required to protect the engine cooling system from fouling, solder blooming and general corrosion. The filter is required to protect the cooling system from abrasive materials, debris, and precipitated coolant additives. The coolant filter must be changed at each oil change interval.
- Engine oil level
 - The pistons are partially cooled by a constant spray of oil received from oil cooling nozzles directed towards the undersides of the pistons. If the engine is run with inadequate quantities of oil present, the pistons can suffer catastrophic failure. Appropriate oil levels must be maintained; oil must be checked and replenished as required daily.
- Diagnostic codes and warning lamps
 - When an engine fault is detected, a warning lamp will turn "ON" or "ON FLASHING" for more severe faults that can have an effect on engine operation and need <u>immediate attention</u>. Active fault conditions must be corrected as soon as possible.

Executive Management and Policy Issues	5

Executive Overview

Clean Air Initiatives in Egypt have focused on reversing the deterioration of air quality resulting from rapid population growth, increased vehicular transport, and industrial production.

The Government of Egypt (GOE) has recognized the fact that pollution problems caused by traffic congestion and old vehicles will only be controlled by the introduction of new fuels that lower tailpipe emissions.

Traditionally fueled by diesel, transit buses also emit significant amounts of fine particulates, which are known to cause premature deaths and illnesses. In response to emerging evidence of the toxicity of diesel vehicular emissions, the GOE has introduced compressed natural gas (CNG) buses into the Cairo public transit system to stem increasing air pollution.

Benefits of using CNG buses:

- Air Quality CNG buses have superior emissions to all commercially available alternatives. In some countries the use of cleaner fuels such as natural gas is mandated by governments.
 - The environmental emissions from the CNG buses when compared to diesel are:
 - Half the nitrogen oxides (NOx)
 - Less hydrocarbons
 - Less carbon monoxide
 - No black fumes or unpleasant odors
- ♣ Reduced Particulate Matter the emission of particulate matter in the latest generation of CNG bus engines is almost below detection levels.
- ♣ Reduced Air Toxins natural gas does not contain toxins to any significant degree thus does not produce the air toxins that threaten health and the environment.
- ♣ Economics in many countries, natural gas is significantly cheaper than diesel so there are major economic advantages in using natural gas.
- ♣ Domestic Resource in many countries that lack domestic oil resources, natural gas is a significant fossil fuel resource, hence its use gives these countries certain security against shortages and crude oil price variations.
- ♣ Climate Change and Reduced Greenhouse Gas Emissions analysis in many parts of the world generally confirms that from production, distribution to end-use, the use of natural gas results in lower overall emission of greenhouse gases, savings being cited typically as about 10%.

Based largely on the local end users' experiences, the following sections discuss some of the key barriers to expansion of the CNG transit fleet and possible steps that can be taken to overcome those barriers. This will enable staff to evaluate future proposals and incentive programs involving CNG buses with expanded knowledge and help ensure that future funding efforts are expended towards the most efficient and cost-effective methods of expanding and maintaining CNG bus fleets.

- ♣ The Government of Egypt must clearly define what success means to their public transit companies. In addition to the "normal" goals of providing safe, reliable and cost effective transportation, providing benefits of improved air quality should be considered as part of the success criteria.
- If daily revenue goals are not met, workers lose their bonuses which can amount to 50% of their wages. This policy encourages staff to roll out the buses regardless of pending maintenance requirements. The potential financial penalties are so severe that this policy works against the best interests of maintaining the CNG fleet. An incentives program to reward the proper operation and maintenance of the buses among the organizations' CNG teams is highly recommended. The establishment of an Employee Recognition and Rewards/Motivation program would likely assist in quality control efforts and would be an important step towards ensuring sustainability of the CNG fleet.

Institutional Sustainability

The challenges of sustainable transportation are immense and will not be solved overnight. Sustainable transportation is a long-term goal, requiring the cooperation of many partners, domestically and internationally, in the search for effective solutions. Progress toward sustainable transportation must be made incrementally. In Egypt, the key will be to better integrate economic, social, and environmental considerations into decisions affecting transportation activity.

Without a strong commitment throughout the organization, the CNG buses will suffer in terms of performance and acceptance, running the risk of being orphaned inside the organization. Key personnel and groups that champion the cause of CNG buses are essential for successful fleets.

High emissions from diesel buses are not merely due to the choice of fuel, but are often symptomatic of deeper problems in the Bus Companies, and these same problems may condemn Natural Gas Bus Programs to failure.

- ♣ Transit operators must be prepared to provide resources, including knowledgeable personnel, time, and funding.
- ♣ CNG has the potential to be a viable alternative to diesel in Cairo and it enjoys strong support from all levels of government. However, the Bus Company Managers often find themselves at cross purposes. Is it their job to move people or deal with environmental issues? If it is the latter, or both, appropriate steps must be taken to clarify what is expected and then to provide the resources to do the job.

Financial Sustainability

Evaluating the costs and benefits of switching from diesel to natural gas for use in buses raises a number of policy issues, ranging from diesel fuel subsidies to import fees. Merely mandating natural gas buses could endanger the success of the natural gas bus program, seriously tarnishing its image in the eyes of not only the stakeholders, but also of the public.

An added consideration is the financial state of the Transit Bus Companies. Lack of an adequate operating budget is one of the reasons for the poor maintenance of diesel buses, resulting in gross emissions. Transit bus fleet operators in poor financial condition are not in a position to take on a CNG bus program successfully. While lack of proper maintenance may not necessarily lead to black smoke emitted by tailpipes in the case of CNG buses, it could easily result in more frequent breakdowns and other operational problems, as well as higher emissions of other pollutants that may become an issue in the long run.

An important driver for the CNG market is the cost advantage of natural gas over gasoline or diesel, although this advantage is diminished in Cairo where the cost of diesel is .40 Egyptian pounds per liter (this price is subsidized). Meanwhile the cost of one cubic meter of natural gas is .45 Egyptian pounds.

Recommendations

The potential fuel cost savings from using CNG will not be realized as long as the subsidy exists for diesel fuel. While diesel is subsidized, it may not be possible to have an enduser price difference between diesel and natural gas that is large enough to achieve a payback. This issue will be addressed further in the Egyptian Environmental Policy Program (EEPP).

The successful development of the market for CNG buses has generally been driven by environmental imperatives to clean up air pollution. Dedicated natural gas engines are being proposed as alternatives to diesel engines in Egypt, primarily for reasons related to air quality. The factors determining the incremental cost difference associated with the use of natural gas engines relative to diesel include:

- ♣ The incremental cost difference of a natural gas engine and associated equipment such as the specialized CNG fuel tanks;
- The cost related to the fueling infrastructure required for use of CNG;
- The cost differential between CNG and diesel fuel; and
- The operating and maintenance cost related to the use of Natural Gas vehicles as compared to diesel vehicles.

It is estimated that the price of Compressed Natural Gas, CNG, would need to be about half that of diesel to make CNG operation financially competitive.

Worldwide experience on the environmental implications of urban buses offers some valuable lessons:

- ♣ Imposing high vehicle standards without attention to the financial sustainability of bus operations can undermine their viability with counterproductive effects.
- Improving the efficiency of bus operations is critical to the sustainable environmental improvement of bus transport.

For a natural gas vehicle program to be financially sustainable in the long run, the incremental cost must be recovered in the form of fuel cost savings, possibly supplemented by a vehicle tax difference in favor of natural gas vehicles.

The viability of a Natural Gas Vehicle Program therefore rests critically on the fuel and vehicle taxation policy adopted by the government, the first of which determines the relative prices of fuels. This issue will be discussed further in the Egyptian Environmental Policy Program (EEPP).

The cost of the fueling infrastructure is a moot point for the public transit companies in Cairo as they are provided at no cost by the gas companies.

The cost of CNG generally depends on the location and availability of the gas as well as local tax policies. In the United States and Argentina for example, where natural gas has a reasonable market share, it tends to cost less than diesel fuel.

In Cairo, the cost of diesel is .40 Egyptian pounds per liter but this price is subsidized. Meanwhile the cost of one cubic meter of Natural Gas is .45 Egyptian pounds.

The potential fuel cost savings from using CNG will not be realized as long as the subsidy exists for diesel fuel. While diesel is subsidized, it may not be possible to have an enduser price difference between diesel and natural gas that is large enough to achieve a payback.

Both bus companies have baseline budgets for the maintenance and operation of their respective diesel fleets. Many of the operating cost are the same (I.E.: tires, brakes, wear and tear on body components such as lights and seating).

A CNG fleet plan must be in place for sustained budget support for appropriate management, continuous technical training, operations and maintenance and after sales service.

This will present a significant challenge for the bus companies given the present circumstances. The bus companies struggle with their existing budgets to be able to maintain their current diesel fleet. The value of the Egyptian pound has diminished significantly over the last two years and this has had a severe negative impact on the operational budgets of both bus companies. Customs fees for imported parts make costs prohibitive and subsequently higher costs are incurred with the CNG fleet. The CNG

infrastructure is in place for both bus companies, but on-going maintenance costs will be incurred for the facilities (I.E.: maintenance of the garage CNG leak detection systems).

Yes, CNG buses cost more to purchase. The operating costs are arguably more, less and/or the same as a diesel fleet dependant upon a variety of factors. Successful transit managers have known the value of training for years. Trained technicians (or the lack of them) can make an enormous difference in operating costs, down time, parts inventory and turn over, fleet reliability and safety.

According to a study conducted by CTA, the annual cost difference (increase) for operating and spare parts for a CNG bus compared with a diesel bus is 20,845 Egyptian pounds (based on 100,000 kilometers traveled per year per bus).

Although it may be arguable that many spare parts consumed may be attributed to inaccurate diagnosis and/or "changing parts until the problem is resolved", the base figure of 20,845 Egyptian pounds per year per bus is not an unreasonable target for budgeting purposes.

Using the cost differential (increase) resulting from CTA's cost analysis provides Senior Managers with a baseline from which they can develop an appropriate operating budget.

Appendices

Appendix I CAIP fleet chronology, a brief history of the CNG Bus Pilot fleet

Cairo Air Improvement Project (CAIP)

The Cairo Air Improvement Project (CAIP) is funded by the United States Agency for International Development (USAID) and implemented in partnership with the Egyptian Environmental Affairs Agency (EEAA) and the Ministry of Petroleum (MOP). Its goal is to initiate and implement measures to reduce air pollutants that have the most serious impact on human health in Greater Cairo. The prime contractor, Chemonics International, provides technical expertise, project management, training, and equipment procurement in support of the GOE in its environmental objectives.

The GOE and USAID have been working together to reduce harmful emissions from diesel-fueled buses through the introduction of a CNG Pilot Bus Fleet program.

The primary goal of CAIP's CNG Component is to reduce particulate emissions from diesel fleets by expanding the use of CNG fuel in public bus fleets, thus, encouraging institutions with large fleets to follow suit.

The CAIP CNG Component has introduced, supported, and demonstrated CNG-fueled pilot test fleets for both the Cairo Transit Authority (CTA) and the Greater Cairo Bus Company (GCBC). CTA and GCBC now maintain and operate pilot fleets of 25 CNG-fueled buses each at newly constructed CNG garages.

Each CNG bus was assembled from a U.S.-manufactured rolling chassis imported from ThomasBuilt Buses and powered by a Cummins C Gas engine. The bus bodies were built in Egypt by the Engineering Automotive Manufacturing Company (EAMC), formerly known as NASCO. The CNG Pilot Bus Fleet Program commenced in 1998 with the first of 50 CNG rolling chassis being delivered to Cairo. Based on the schedules defined largely by the Cairo transit bus companies themselves, buses began service from October 2000 to December 2001. The CNG Pilot Bus Fleet is the first US-Egyptian bus fleet of its kind.

In an effort to integrate CNG industry best standards and practices into the existing maintenance and operating procedures of CTA and GCBC, CAIP developed a Maintenance and Operating Recommendations Manual for the garages. The recommendations included operational and safety procedures, management policies, and preventative maintenance and inspection programs. Extensive advanced training has been provided to CTA and GCBC personnel in the maintenance, operation, and repair of the CNG bus fleet. CAIP also worked closely with the GOE in developing Egyptian National CNG Safety Standards.

Evidence of Egypt's strong commitment to using CNG in the transit system can be seen in the various expansion and sustainability measures being taken by the government and private sector partners. While the conversion from diesel to CNG technology is still a new trend globally, Egypt is making great strides to place itself at the forefront of the movement. The introduction of the 50-bus CNG Pilot Bus Fleet and the development of Egyptian National CNG Safety Standards have formed a solid foundation for the development of related environmentally friendly industries. Development of these

industries is accompanied by an ambitious Ministry of Petroleum plan for new natural gas exploration and the construction of the related infrastructure, such as natural gas pipelines and fueling stations.

The following is a summary of CAIP CNG Pilot Fleet activities:

- Supply CNG pilot Fleet
 - Procure 50 Rolling Chassis
 - Procure Vehicle Gas Leak Detection Systems
 - Assist in Procuring Bus Bodies
 - Assist in Production of Prototype Bus
 - Conduct Preliminary Testing of First Prototype Bus
 - Integrate Rolling Chassis and Bodies
 - Procure Rolling Chassis Spare Parts
- Provide Assistance in Building CNG Maintenance Facilities
 - Assist in Building Maintenance Garages
 - Assist in Construction of CNG Fueling facilities
 - Supply Garage Equipment
 - Provide Safety Equipment
- Provide Training and Institutional Support
 - Develop Training Plan
 - Provide CNG Bus Training
 - Provide CNG Cylinder and Fuel System Training
 - Provide CNG Equipment Training
 - Develop Operations and Maintenance Procedures
 - Develop/Implement Computer Maintenance Management System

The CNG Pilot Fleet Project

CAIP has worked closely with all stakeholders throughout this project. The challenges were faced head-on and the spirit of cooperation has been commendable from all parties. The bus companies have overcome many obstacles during this process. That is not to say that there is not work ahead, but what has been accomplished is something for which the bus companies should be commended. The CNG pilot fleet has accumulated in excess of 10 million kilometers, testimony to the high demands placed on the fleet.

The level of interest displayed by the managers, engineers and technicians shows a deep level of commitment towards making CNG a viable alternative to diesel for the public transit fleet.

Although CAIP is not an institutional capacity strengthening project, there will be observations and comments reflected in this document that touch briefly on such issues. Certain impediments currently affect all the stakeholders in moving forward with the expanded use of CNG in the public transit system. A policy framework to support the

expansion of CNG buses in Egypt will be addressed in greater detail under the Egyptian Environmental Policy Program (EEPP).

Mandates to use CNG may work, but both bus companies agree that economic incentives are necessary for long term sustainability. In addition, the issue of diesel subsidies and Customs fees for imported CNG parts must be addressed.

Public Transit Buses in Cairo

It is important to understand the operating environment into which the CNG pilot fleet was introduced. An intensive study was completed in 1993 that addressed public transit in metropolitan Cairo. The study addressed many issues regarding the maintenance and operation of the public transit *diesel* fleet. Many of the deficiencies that were observed at that time still exist:

- ♣ The majority of breakdowns were identified as being due to a serious shortage of skilled labor and supervisors (inefficiencies in periodic maintenance were identified as the main cause for premature engine failures).
- ♣ The overall expenditures for parts utilization were determined to be high. This was a reflection of problems with parts quality and poor maintenance practices. Maintenance issues were commonly addressed by changing a series of parts until the problem went away, rather than diagnosing the fault and implementing only the repairs that were necessary.
- ➡ The need was identified for a properly planned and managed preventive maintenance program together with continued training of key workers, supervisors, engineers and managers at all levels in the bus organization.
- ♣ The buses operated an average of 16 hours per day. The high operating hours impacted the time available for performing routine maintenance and repair activities.
- ♣ A large number of the existing diesel public transit fleet was consistently unavailable for service due to maintenance problems.
- Fleet utilization was reduced by daily "on the road" failures.

Both bus companies need to take steps to address the on-going issues (above) that continue to seriously impact fleet safety, reliability and operating costs. These issues will have serious repercussions on any fleet type, whether it is diesel, or CNG.

Introduction of the CNG bus pilot fleet

Several challenges were faced during the initial introduction of the CNG Pilot Fleet:

- ♣ One CNG fueling facility was discovered to have been dispensing low quality fuel. This resulted in severe engine damage to several CNG engines and it took some time to get that portion of the fleet back in running order. All of the engines which were exposed to the low quality fuel, needed to be partially disassembled, inspected for damage and repaired as necessary.
- ♣ ThomasBuilt (the rolling chassis manufacturer) was purchased by Freightliner. Consequently, Freightliner assigned a new local dealer for chassis warranty. (This work was previously assigned to ADATCO, the local Cummins and Freightliner dealer). The new dealer (Triangle) had a steep learning curve to overcome. They initially failed to stock adequate spare parts and this created numerous delays in repairing buses.
- Cummins replaced their local dealer. The local dealer that was replaced (ADATCO) also had a long history of problems stocking adequate spare parts and this created numerous delays in repairing buses.
 - It took some time for the new dealer (Egyptian International Motors/EIM) to get the inspection and repair done on the CNG engines that were exposed to low quality fuel; and to be trained on the new CNG technology.
- ➡ El NASR Automotive Manufacturing Company/NASCO (the local bus manufacturer) caused many delays in delivering the completed bus to the customers.
 - Unskilled workers and poor workmanship resulted in many damaged components during the integration of the body onto the rolling chassis. These issues took an extraordinary amount of time to resolve as discussions with vendors and parts availability continuously hampered expeditious repairs.
- ♣ Several unanticipated challenges were experienced on the ThomasBuilt (TBB) rolling chassis. CAIP provided technical expertise in diagnosing the reasons for premature failures on many components and systems on the TBB rolling chassis and worked closely with suppliers and contractors to initiate repairs.

TBB campaigned the following:

- Fuel lines and connectors
- Fuel regulators and solenoids
- Alternators and brackets
- Leaf springs
- Brake brackets

Oil in fuel

Two gas companies (NGVC) and Gastec) provided gas dispensing facilities for fueling the CNG buses. CAIP worked with the gas companies to minimize the amount of oil being introduced into the compressed natural gas during the compression cycle. If the dispensing facilities are not carefully maintained, the amount of oil introduced into the fuel stream on the CNG buses can have severe negative impacts on the vehicle CNG fuel system and components. Subsequently, the bus companies increased the frequency of draining and changing the bus fuel filters to assist in minimizing the amount of oil being introducing into the bus fueling system.

CNG engine failures

Initial premature engine failures were attributed to low quality gas at one fueling site. This was immediately remedied.

- Subsequent engine failures resulted in Cummins providing newly designed and upgraded piston sets for the entire fleet.
- The quality of maintenance provided at the bus companies also contributed to several premature engine failures.

Appendix II Vendor contact information

Allison Transmission

Carline Middle East Co.
 Parts &Service Manager Engineer Salah Kamel
 Telephone: 570-3511/12/13/14

Fax: 570-3515

Amerex Vehicle CNG Leak Detection System

 Vice President, Floris Van Os 7595 Gadsden Highway East Trussdale, Alabama, U.S.A. Telephone: 205-655-3271 Fax: 205-655-0854

Ari Hetra Portable Wheel Lifts

 BECTA International, George Saad 102 Mir Ghany St Heliopolis, Cairo, Egypt Telephone: 521-2175/012-234-2056 Email: bectai@yahoo.com

Ari Hetra Lifts (U.S.A.),
 National Account Manager, Tony Chowney Email: chowney@ari-hetra.com
 Automotive Resources, Inc.
 9990,Lee Highway, Suite 160
 Fairfax, Virginia, U.S.A. 22030-1720
 Telephone # 703-359-6265
 Fax# 703-359-6405

Ari Hetra Lifts (U.S.A.),
 National Account Manager, Tony Chowney Email: chowney@ari-hetra.com
 Automotive Resources, Inc.
 9990,Lee Highway, Suite 160
 Fairfax, Virginia, U.S.A. 22030-1720
 Telephone # 703-359-6265
 Fax# 703-359-6405

Cummins Engine Company

Egyptian International Motors
 Parts General Manager, Khaled El Nemr, 506-1600/601

General Manager, Badawi Badran, 506-1600/601-082

Fax: 5119397

Division Mgr., Ahmed Hamsa, 5090020/026

Cummins Engine Company Ltd.

John A. Saunders, General Manager Africa

Royal Oak Way South

Daventry, Northants NN11 5 NU

England

Direct Office: (44) 1327 886396

Mobile: (44) 468 274531 Fax: (44) 1327 886102

Email: John.a.saunders@cummins.com

CTA facility leak detection system

Target Engineering
 A. Momen Helmy
 14 St. 286
 Cairo - Egypt

Telephone: 516-7711/516-7621

Fax: 516-4044

Freightliner chassis local dealer, Tri-Angle

After Sales Manager, Said El Gohary, 8323886/7
 Technician, Atef,
 Manager, International Sales, Adel Yasso, 5263800 (ext.212)

Freightliner chassis local dealer, Tri-Angle

After Sales Manager, Said El Gohary, 8323886/7
 Manager, International Sales, Adel Yasso, 5263800 (ext.212)

GCBC facility leak detection system

Dawliya Engineering Division

Motaz El-Manialawi

21. Mohammed Saeed Alhalawany St,

Airport Road, Cairo, Egypt

Telephone: 268-1366

Fax: 266 3779

General Dynamics (previously Lincoln Composite Tanks)

Ken C. Halvorsen

Technical Service Engineer NGV Product Group

4300 Industrial Avenue

Lincoln, NE 68504-1197 Office 402 465 6527

Fax: 402 464 6777

Email: khalvorsen@gdatp.com

Christine Simetich

Manager, Business Development

General Dynamics

4300 Industrial Ave.

Lincoln, NE 68504

Office 402-465-6529

Fax: 402-464-6777

Email: csimetich@gdatp.com

Rotary Parallelogram Lifts

■ El Bassiouni & Company

74 Abd El Moniem Riad Street

Agouza, Cairo, Egypt

Telephone: 347-6682/304-3813

Fax: 303-18983

Email: basionco@thewayout.net

Swagelok Egypt (CNG fittings)

Sales Manager, Amr Kamel, 6435073
 Sales Engineer, Yousry Salama, 6435073

Thermo King Air Conditioning

Vice President, Ehab El-Tahhan

5 St. #293

New Maadi, Cairo, Egypt Telephone: 518-2795/0145

Fax: 517-1925

Email: eetahha@tk-net.com

Appendix III Training

One of the important components of a successful natural gas vehicle program is extensive training of maintenance technicians and drivers, and the availability of qualified engineers for technical support. Training is needed not only for proper maintenance and safe operation of vehicles, but also to dispel misperceptions and build the acceptance and commitment of the operators involved.

Significant technical training was provided for key staff at both garages. The training topics included but were not limited to:

- Basic fleet maintenance management
- Electronic systems (I.E.: CNG engine computerized trouble shooting software and electronic engine controls)
- CNG fuel cylinder familiarization, inspection and repair techniques.
 - Staff from each garage has been certified by the CNG cylinder manufacturer in the inspection methods necessary to ensure system safety. In addition, staff from each of the two gas companies has been certified by the CNG cylinder manufacturer in repair techniques and in the necessary steps for recertifying the CNG fuel cylinders (required every 36 months)
- ♣ ThomasBuilt rolling chassis familiarization and maintenance requirements
- Vehicle CNG leak detection system
- CNG engine familiarization and maintenance requirements
- Special equipment familiarization and maintenance requirements, including new parallelogram and portable wheel lifts, coolant recovery system and facility CNG leak detection system

Copies of all of training materials for each course have been provided to the bus companies. A comprehensive list of courses provided and attendees is attached with this report.

Training Summary

Compressed Natural Gas Training

Compressed Natural Gas Training							
Caa	Data	End	Dti	No. Of		Location	
Course	Date	date	Duration	Participants			
(Performance based)			_	СТА	GCBC		
Trouble Shooting for Drivers	6/13/99	6/14/99	2	0	4	Cairo	
Prototype Bus seminar	2/27/00	2/27/00	1	7	2	Cairo	
RC Training for O & S - Course 1-PH1	2/29/00	3/2/00	3	17	9	Cairo	
RC Training for Management staff- PH I	1/24/00	1/26/00	3	17	15	Cairo	
RC assembly & testing OST	9/27/99	10/10/99	14	13	2	USA	
RC Training for O & S - Course 2-PH1	2/29/00	3/6/00	3	8	7	Cairo	
RC Inspection Orientation	12/6/99	12/6/99	1	22	6	Cairo	
5 Demo Buses O&M session 1	11/15/98	11/21/98	6	2	1	Cairo	
5 Demo Buses O&M session 2	11/29/98	12/7/98	6	3	8	Cairo	
RC - Phase I - Session 1- Tech.	5/23/00	6/7/00	12	13	14	Cairo	
RC Phase I - Session 2-Eng.	6/11/00	6/27/00	12	6	3	Cairo	
RC Phase I - Session 2-Tech.	6/27/00	7/12/00	12	16	10	Cairo	
RC - Phase I - Session 1- Eng.	5/7/00	5/22/00	12	10	5	Cairo	
Creative Thinking workshop	10/12/99	10/12/99	1	0	1	Cairo	
RC - Basic Electric for Engineers (phase 2)	9/10/00	9/11/00	2	5	4	Cairo	
RC - Trouble Shooting for Engineers (phase 2)	9/20/00	9/24/00	3	6	4	Cairo	
RC - Basic Insite for Engineers (phase 2)	9/14/00	9/17/00	3	6	4	Cairo	
RC- CNG and Engine Systems for Engineers	9/18/00	9/19/00	2	6	4	Cairo	
RC - Electrical Systems and Control for Engineers	9/12/00	9/13/00	2	6	4	Cairo	
RC - Axles, Suspension, Breaking and Steering	8/30/99	8/30/99	1	6	4	Cairo	
RC Ph II Training for Drivers Trainers (Session 2)	9/20/00	9/20/00	1	6	6	Cairo	
Lift Training Workshop	10/15/00	10/21/00	4	5	5	Cairo	
RC Ph II Transmission for Engineers	9/22/00	9/26/00	5	5	4	Cairo	
RC Ph II Transmission for Technicians	10/29/00	11/2/00	5	9	3	Cairo	
RC Ph II Engine Troubleshooting for	10/23/00	10/24/00	2	6	3	Cairo	
RC Ph II Engine Troubleshooting for Technicians	10/25/00	10/26/00	2	8	3	Cairo	
RC Ph II CNG & Engine Systems for Technicians	10/17/00	10/22/00	3	15	1	Cairo	
RC Ph II Basic Electric for Technicians	10/11/00	10/12/00	2	11	9	Cairo	
RC Ph II Axles, Brakes, Suspension, & Steering	10/8/00	10/10/00	3	9	9	Cairo	
RC Ph II Training for Drivers Trainers (Session 1)	9/20/00	9/20/00	1	12	5	Cairo	
Recycling Coolant Training Program	1/23/01	1/25/01	3	7	5	Cairo	
Inspection and Maintenance of Transit	3/26/00	3/29/00	3	14	9	Cairo	
Lincoln Composites NGV Fuel Container Training	7/31/01	7/31/01	1	4	4	Cairo	
Mobile Lift Training	1/13/02	1/13/02	1	6	7	Cairo	
Safety Equipment Training for GCBC	3/24/02	3/25/02	2	0	12	Cairo	
CNG Stakeholders Meeting			1		2		
	5/28/02	5/28/02	2	3	0	Cairo	
Surveillance System Training	7/21/02 9/8/02	7/22/02				Cairo	
CMMS Training for GCBC	1	9/30/02	16	0	8	Cairo	
CMMS Training for CTA	7/26/02	8/26/02	29	14	0	Cairo	
Cummins Insite & Maintenance Training	1/5/03	6/1/03	2	4	0	Cairo	

		End		No	No. Of	
Course	Date	date	Duration	Participants		Location
(Performance based)				CTA	GCBC	
Cummins Training for Engineers	8/25/02	8/26/02	2	5	3	Cairo
Cummins Training for Technicians	8/27/02	8/28/02	2	12	6	Cairo
Quality Assurance and Enhanced Fleet	9/29/02	10/3/02	5	12	7	Hurghada
CMMS Training for Network Administrators	8/27/02	8/31/02	5	4	4	Cairo
Cummins Insite & Maintenance Training	1/8/03	1/9/03	2	10	0	Cairo
Computer (General Capacity Building)						
Computer Training - Windows (1st Round / Eng.)	6/3/00	6/17/00	7	5	1	Cairo
Computer Training - Word (1st Round /	6/19/00	7/3/00	7	5	1	Cairo
Computer Training - Excel (1st Round /	7/5/00	7/19/00	7	5	1	Cairo
Computer Training - Excel (1st Round / Admin &	7/6/00	7/20/00	7	2	4	Cairo
Computer Training - Word (1st Round / Admin &	6/20/00	7/4/00	7	2	4	Cairo
Computer Training - Windows (1st Round / Admin	6/4/00	6/18/00	7	2	4	Cairo
Computer Training - Windows (2nd Round /	7/25/00	8/8/00	7	3	3	Cairo
Computer Training - Windows (2nd Round /	7/26/00	8/9/00	7	0	2	Cairo
Computer Training - Word (2nd Round / Admin &	8/10/00	8/24/00	7	3	3	Cairo
Computer Training - Word (2nd Round /	8/12/00	8/26/00	7	0	2	Cairo
Computer Training - Excel (2nd Round / Admin &)	8/27/00	9/10/00	7	3	3	Cairo
Computer Training - Excel (2nd Round / Eng.)	8/28/00	8/11/00	7	0	2	Cairo
Computer Training - Power Point 1	10/22/00	10/31/00	8	2	0	Cairo
Computer Training - Access 1 (Group 1)	11/4/00	11/25/00	10	4	0	Cairo
Computer Training - Windows (3rd Round/ Eng.	117 1700	11/20/00	10			Cano
8	10/10/00	10/19/00	5	2	7	Cairo
Computer Training - Word (3rd Round/ Eng. &	10/23/00	11/8/00	8	3	8	Cairo
Computer Training - Excel (3rd Round/ Eng. &	11/11/00	11/27/00	8	3	5	Cairo
Computer Training - Excel (3rd Round/ Eng. &	11/9/00	11/25/00	8	2	6	Cairo
Computer Training - Word (3rd Round/ Eng. &	10/22/00	11/7/00	8	3	5	Cairo
Computer Training - Windows (3rd Round/ Eng. &	10/11/00	10/21/00	5	3	6	Cairo
Computer Training - Power Point 2	2/4/01	2/14/01	8	4	0	Cairo
Computer Training - Tower Tollit 2 Computer Training - Access 2	4/4/01	4/22/01	12	5	1	Cairo
Introduction and Orientation to Computer for	4/4/01	4/22/01	12	5	ı	CallO
CTA	7/9/01	7/10/01	2	0	9	Cairo
Introduction and Orientation to Computer for CTA	7/11/01	7/12/01	2	9	0	Cairo
Introduction and Orientation to Computer for	7,11,01	7,12,01			<u> </u>	Julio
GCBC	7/16/01	7/17/01	2	0	10	Cairo
Introduction and Orientation to Computer for GCBC	7/18/01	7/19/01	2	0	9	Cairo
Computer Training - Power Point 3	3/20/02	4/6/02	10	3	2	Cairo
Computer Training - Internet 2	1/23/02	2/2/02	5	6	1	Cairo
Computer Training - Advanced Excel	4/21/02	5/13/02	10	3	0	Cairo

Computer (General Capacity Building)				СТА	GCBC	
Computer Training - Data Acquisition and	4/27/99	4/29/99	3			Cairo
Computer Training - Basic Skills 1						
(CTA/CMMS) -	6/11/02	7/1/02	15	13	0	Cairo
Computer Training - Basic Skills 2 (GCBC/CMMS)	6/18/02	7/15/02	20	0	8	Cairo
Computer Training - Visual Basic I	7/21/02	8/3/02	10	2	0	Cairo
Visual Basic Training 2	10/5/02	10/21/02	10	4	0	Cairo
Computer Training -Advanced Data Acquisition	12/4/98	12/18/98	15	1	0	USA
Computer Training-Microsoft Certified System	11/16/02	1/19/03	36	1	2	Cairo
Computer Training - Excel (June 2003)	6/15/03	6/19/03	5	2	2	Cairo
Computer Training - Power Point XP	7/13/03	7/16/03	4	2	2	Cairo
Cross Cutting (General Capacity Building)						
Strategic Evaluation and Analysis	6/2/02	6/3/02	2	3	1	Cairo
Teambuilding and Coordination	6/23/02	6/25/02	2	5	5	Cairo
Action Planning	8/4/02	8/6/02	3	1	1	Cairo
Team Building & Coordination - IT1	7/7/02	7/9/02	3	3	1	Cairo
Team Building & Coordination - IT2	6/30/02	7/2/02	3	3	1	Cairo
Team Building & Coordination - IT3	6/23/02	6/25/02	3	4	5	Cairo
Monitoring & Evaluation Systems Training-IT1	9/7/02	9/9/02	3	1	1	Cairo
Monitoring & Evaluation Systems Training-IT2	9/10/02	9/12/02	3	1	1	Cairo

Lincoln Composite CNG Cylinders must be inspected, repaired and/or replaced only by authorized personnel. Responsibilities and Authority for CNG Fuel System work is defined as follows:

Only authorized CTA/GCBC persons are allowed to:

- ♣ Inspect Lincoln composite CNG cylinders
- ♣ Change or re-secure a CNG line or CNG Cylinder Mounting Strap
- Vent Fuel

CTA Trained and authorized personnel:

Eng. Sedky Ezzat Mansour
Eng. Wagdy Mohamed Abdel Wahab
Mr. Abdel Aziz Sayed
Mr. Ezzat Saad Salem

GCBC Trained and authorized personnel:

Eng. El Sayed Ali Ibrahim
Eng. Shahhat Mohamed Ibrahim
Mr. El Sayed Labib Ahmed
Mr. Alaa Khairy Abdel Fattah

Only authorized NGVC and Gas tech persons are allowed to:

Inspect Lincoln composite CNG cylinders

- ♣ Change or re-secure a CNG line or CNG Cylinder Mounting Strap
- Replace a Pressure Relief or Fuel Fill Valve
- Vent Fuel
- ♣ Re-Certify Lincoln Composite CNG Cylinders
- ♣ Remove Lincoln Composite CNG Cylinders
- ♣ Install Lincoln Composite CNG Cylinders
- ♣ Repair Lincoln Composite CNG Cylinders

NGVC and Gas Tech Trained and authorized personnel:

NGVC
Eng. Ahmed Mahmoud El Sayed
Eng. Mohamed Bahgat Abdel Hamid
Mr. Hamdt Fayiad
Mr. Mustafa Awad
Gas Tech.
Eng. Taha Ahmed Mahmoud Ahmed
Eng. Khaled Abdel Aziz Hussein
Mr. Sayed Ahmed Sayed
Mr. Mohamed Mohamed Abdel Hady Haridy

Note: All Lincoln Composite CNG Cylinders shall be inspected and re-certified every 36 months by authorized personnel.

Appendix VI Documents delivered to CTA & GCBC

After sales service

Major suppliers that support the CNG pilot fleet have worked closely with CAIP and the bus companies. Contact information for each supplier has been provided to both bus companies and has been included in appendix II of this report.

Original Equipment Manufacturers (OEM) manuals

Maintenance, troubleshooting and parts manuals have been provided for buses and all support equipment to CTA and GCBC. Additional copies have been provided to CTA and GCBC with this report.

The documents include:

- ThomasBuilt Original Equipment Manufacturer Maintenance Manuals
- Maintenance and Operation manuals for Ari Hetra bus lifts
- Operations, Maintenance and troubleshooting guide for Rotary bus lifts
- Installation Guide for Rotary bus lifts
- Operations and Maintenance manual for ThomasBuilt bus developed by CAIP
- Operators manual for ThomasBuilt Bus
- ♣ NGV Fuel Tank (CNG) Inspection Guidelines
- ♣ Troubleshooting & Vehicle Repair Manual for Cummins C8.3G Engine
- ♣ Operation & Maintenance Manual for Cummins C8.3G Engine
- Installation, Operation & Maintenance Manual for AMEREX Gas Detection System
- Owner Manual foe AMEREX Gas Detection System
- TAS Steering Gear Service Manual
- Eaton (axles & brakes), Service Manual
- Eaton (axles & brakes), Parts List